

AIRBORNE COLLISION AVOIDANCE SYSTEM II (ACAS II) - PILOT TRAINING.

1 Introduction

1.1 ACAS II is an aircraft system based on Secondary Surveillance Radar (SSR) transponder signals from aircraft, and operating independently of ground-based equipment to provide advice to pilots on potential conflicting aircraft and will be referred to throughout this document as ACAS. ACAS provides a 'safety net' against the risk of mid-air collision should the normal means of providing separation between aircraft fail. The importance of correct and timely crew response to ACAS alerts and warnings cannot be over-emphasised. Thus the human interface with this equipment is fundamental to the ACAS 'safety net'.

1.2 The purpose of this Circular is to serve as a reminder that effective ACAS training is crucial to ensuring that pilots correctly interpret and react to Traffic Advisories (TAs) and Resolution Advisories (RAs). A clear understanding of the definitions, system operations and operating procedures is vital if ACAS is to achieve safety benefits. It is essential that every flight crew member of an aircraft equipped with ACAS has been trained to competency in the use of this equipment and in the avoidance of collisions. Advances in technology in the form of automated ACAS response will influence the situation further and should be closely monitored.

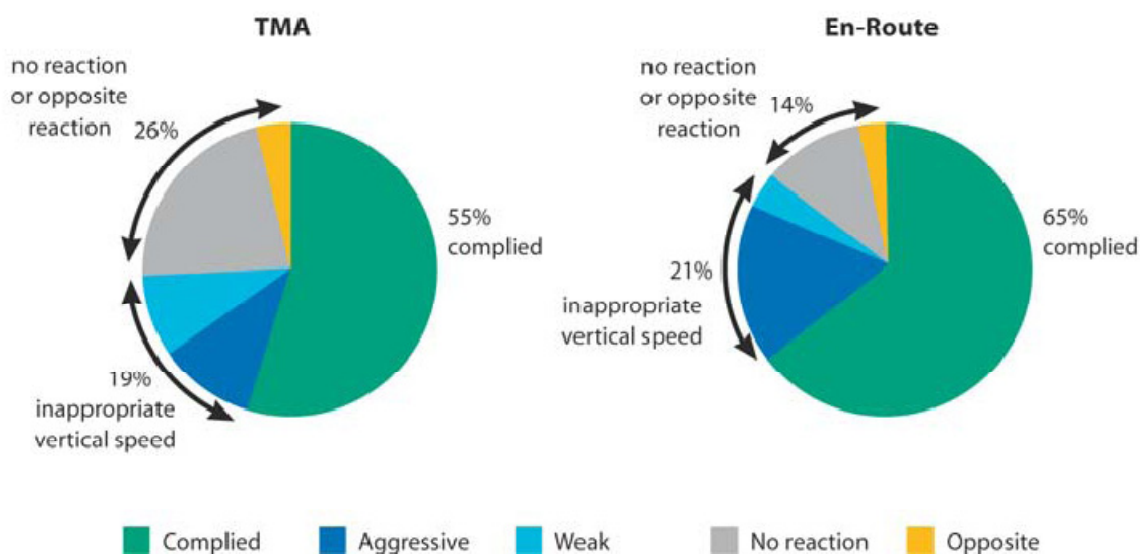
2 Pilot Response to ACAS RAs

2.1 A 1 January 2000 mandate required all aeroplanes powered by jet or by turbo-prop engines having either a Maximum Take-Off Weight (MTOW) in excess of 15,000 kg or a capacity of 30 plus passengers to carry ACAS II. The mandate was extended on 1 January 2005 to include all civil turbine powered aeroplanes with an MTOW in excess of 5700 kg or a capacity greater than 19 passengers. Use of ACAS II has been mandated for over ten years, yet situations involving inappropriate pilot responses are still being reported. For example, a recent investigation of an event in the UK found that an overseas crew elected not to respond to an ACAS RA on the grounds of 'passenger comfort'. Discussions during safety presentations at numerous recent pilot forums indicate that confusion still remains over basic aspects such as the meaning of, and appropriate response to, an 'Adjust Vertical Speed' aural alert for example.

2.2 Inappropriate crew responses have led to severe losses of separation or, in the extreme, an accident. Recent research by EUROCONTROL based on sample data from Central Europe and the UK suggests that climb/descend RAs are correctly complied with in 65% of cases in en-route airspace and only 55% of cases in Terminal Manoeuvring Areas (TMAs). Correct and timely crew reaction to ACAS RAs is vital if standards of operational safety are to be maintained. The potential consequences of not reacting to an RA are clear, and responses that are too weak or too aggressive can have a negative impact on the effectiveness of ACAS. The EUROCONTROL report and subsequent presentation to the European Aviation Safety Agency (EASA) can be found on the EUROCONTROL website at:

http://www.eurocontrol.int/msa/public/standard_page/ACAS_Investigation_analysis.html

2.3 The broad details of the report's findings are reproduced diagrammatically below:



Reaction to RAs in TMAs (<FL135) and in En-Route airspace (> FL135)

2.4 Pilot response to ACAS RAs, lessons identified and the key aspects of training are discussed in more detail in EUROCONTROL ACAS Bulletin 12 which can be found on the EUROCONTROL website at:

http://www.eurocontrol.int/msa/gallery/content/public/documents/ACAS_bulletin_12.pdf

3 CAA Action

3.1 The CAA is working to establish a better understanding of pilot response to ACAS RAs within the UK and seeks to develop a baseline against which future performance in this regard can be monitored. The topic will also be reviewed by the UK Flight Data Monitoring (FDM) Users Group in a bid to establish whether any trends are forthcoming and to better understand how operators monitor crew performance in this area. A recent training and standardisation event for CAA Flight Crew Standards and Flight Examiners involved a lengthy and detailed session based on pilot response to ACAS RAs and sought to raise awareness of key safety issues. The prime aim of the session being to ensure that CAA training/examining staff are better placed to encourage the maintenance of high standards relating to ACAS during the course of their work with trainers and crews in industry. By way of concurrent activity a sampling project is underway to establish the capability of a variety of simulator types to provide realistic and effective ACAS training for crews. This project will also take into account opportunities that may exist via the use of desk top training aids. A good example of an alternative training method is the computer based system used by the National Flying Laboratory Centre (NFLC) at Cranfield University which operates an aircraft type that does not allow for simulator based ACAS training. The CAA will continue to work closely with industry on the topic and will seek to make appropriate recommendations as the ACAS work comes to fruition and thereafter.

4 Training Guide

4.1 The International Civil Aviation Organization (ICAO) guidelines for pilot training on ACAS / TCAS are contained in Chapter 5 of Doc. 9863 (ACAS Manual) and in the attachments to Doc. 8168 (PANS-OPS). These guidelines stipulate both practical manoeuvre training using aircraft simulators (or suitable Computer Based Training (CBT)) and theory training for pilots. ACAS should be included in recurrent training sessions and flight crews must be tested to ensure they are fully conversant with ACAS procedures, capabilities and limitations, and that they are able to respond correctly to TAs and RAs.

4.2 The ICAO guidelines list 22 learning points relating to operational use and four items of best practice. Training objectives cover theory of operations, pre-flight operations, general in-flight operations, and responses to TAs and to RAs.

4.3 Essential academic training includes, amongst other items:

- System operation: advisory thresholds; ACAS limitations; ACAS inhibits;
- Operating procedures: use of controls; display interpretation; use of the TA-only mode; crew coordination; reporting requirements;
- Manoeuvre training: scenarios which verify pilot interpretation and responses to both TAs and RAs. The scenarios should include: initial RAs that do and don't require a change in vertical speed; maintain rate RAs; altitude crossing RAs; increase rate RAs; RA reversals; weakening RAs; RAs issued while the aircraft is at a maximum altitude; and multi-aircraft encounters. The scenarios should also include demonstrations of the consequences of not responding to RAs, slow or late responses, and manoeuvring opposite to the direction called for by the displayed RA.

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- 4.4 The EASA requirement for ACAS will be laid down in Part-AUR, Part-ACAS and is expected to come into force in March 2012.
- 4.5 The main elements of Flight Crew Training Notice 06/2009 ACAS Training have been reproduced at Annex A to this Circular.

5 References

5.1 Related Articles

- ACAS Regulation and Procedures:
http://www.skybrary.aero/index.php/ACAS_Regulation_and_Procedures
- Incorrect use of TCAS Traffic Display:
http://www.skybrary.aero/index.php/Incorrect_use_of_TCAS_Traffic_Display
- ACAS: Guidance for Controllers:
http://www.skybrary.aero/index.php/ACAS:_Guidance_for_Controllers

5.2 Related Media

- TCAS Awareness Videos:
<http://www.skybrary.aero/index.php/Solutions:TCAS>

5.3 Further Reading

- 5.3.1 ICAO Doc 9863 (ACAS Manual), Chapter 5 - Operational use and pilot training guidelines;
ICAO Doc 8168, Attachment A - ACAS training guidelines for pilots;
ICAO Doc 8168, Attachment B - ACAS performance during HVR encounters;
ICAO Doc 9863 (ACAS Manual), Chapter 6 - Controller training guidelines.

Overview of ACAS II/TCAS II:

<http://www.skybrary.aero/bookshelf/books/1445.pdf>

EUROCONTROL ACAS bulletins, especially No 12 which deals specifically with Training:

http://www.skybrary.aero/index.php/ACAS_Bulletin_-_EUROCONTROL

EUROCONTROL: ACAS Training Brochure:

<http://www.skybrary.aero/bookshelf/books/106.pdf>

Further details of courses and training material available from EUROCONTROL may be found on the ACAS website:

http://www.eurocontrol.int/msa/public/standard_page/ACAS_Startpage.html

- 5.3.2 AIP ENR 1.1.3 - GENERAL FLIGHT PROCEDURES - Use of Airborne Collision Avoidance Systems (ACAS) in the United Kingdom FIR and UIR.
- 5.3.3 CAA CAP 789 - Requirements and Guidance Material for Operators
- 5.3.4 AIC P 079/2011
AIC P 092/2009
AIC P 122/2007
AIC P 112/2007
- 5.3.5 Flight Crew Training Notice 06/2009

ANNEX A

Performance Based Training Objectives for ACAS II Pilot Training

(Source: CAA Flight Crew Training Notice 06/2009)

1 Training Objectives

1.1 The training objectives should cover the following:

- Theory of operation;
- Pre-flight operations;
- General in-flight operations;
- Response to TAs;
- Response to RAs.

1.2 These training objectives are further divided into:

- Academic training;
- Manoeuvre training;
- Initial training;
- Recurrent training.

2 Academic Training

2.1 This training is typically conducted in a classroom using both computer-based training (CBT) aids and ACAS documentation. The required level of knowledge should be confirmed by means of a written test or interactive CBT questions.

2.2 Theory of Operation

2.2.1 The pilot must demonstrate an understanding of the following:

- a. Surveillance - the range of interrogation by the ACAS of other transponder equipped aircraft. The maximum range of surveillance may be reduced by large numbers of ground interrogators and/or ACAS-equipped aircraft to as little as 4.5 NM;
- b. Collision avoidance:
 - i. What influence the modes of transponder have on the TA presentation;
 - ii. When an RA will only be issued against aircraft that are reporting altitude and only in the vertical plane;
 - iii. How an RA against an ACAS-equipped intruder is co-ordinated to ensure complementary RAs are issued;
 - iv. When the failure to respond to an RA deprives the aircraft of the collision protection provided by the ACAS equipment. Additionally during a co-ordinated RA encounter the failure of one aircraft to manoeuvre in accordance with the RA renders the other aircraft's ACAS less effective than if the first aircraft were not ACAS-equipped;
 - v. When manoeuvring in a direction opposite to that indicated by an RA is likely to result in further reduction in separation. This is particularly true in the case of a co-ordinated RA encounter.
- c. Advisory thresholds:
 - i. A knowledge of the criteria for the issue of TAs and RAs;
 - ii. How ACAS advisories are based on time to Closest Point of Approach (CPA) rather than distance;
 - iii. When separation standards provided by Air Traffic Control (ATC) are different from those against which ACAS issues alerts;
 - iv. The thresholds for issuing a TA or RA vary with altitude. The thresholds are larger at higher altitudes;
 - v. How RAs are chosen to provide the desired vertical separation at CPA. As a result, RAs can instruct a climb or descent through the intruder aircraft's altitude.

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- d. The limitations of the ACAS equipment:
 - i. ACAS will neither track nor display aircraft that are not equipped with a transponder, have an inoperable transponder or have a Mode A transponder;
 - ii. A knowledge of which aircraft system or instrumentation failures will lead to the automatic failure of the ACAS;
 - iii. Due to limited azimuth resolution, the bearing information displayed by ACAS is not sufficiently accurate to support the initiation of horizontal manoeuvres based solely on the traffic display;
 - iv. That stall warning, Terrain Awareness Warning System (TAWS) and wind shear warnings take precedence over ACAS advisories. When a TAWS or wind shear warning is active the ACAS will automatically switch to TA-only mode with the aural annunciation inhibited;
 - v. ACAS will neither display nor give alerts against intruders with a vertical speed in excess of 10,000 feet per minute, for example rapidly climbing or descending military aircraft;
 - vi. ACAS may not display all proximate traffic in areas of high-density traffic;
 - vii. Some aircraft within 380 ft Above Ground Level (AGL) may not be displayed.
 - e. The conditions under which certain functions of ACAS are inhibited:
 - i. Heights above the ground at which various RAs are inhibited;
 - ii. Heights above the ground at which all aural annunciations are inhibited;
 - iii. Altitudes and configurations under which climb and increase climb RAs are inhibited. Manoeuvring in the required sense of the RA, even when the aeroplane performance is not sufficient to satisfy full compliance with the climb rate required by the RA, will still reduce the risk of collision.

2.3 Operating Procedures

2.3.1 The pilot must demonstrate the knowledge required to operate ACAS and interpret the information presented by ACAS. The training should achieve the following:

- a. Enable the pilot to correctly operate the ACAS controls:
 - i. Use of the self-test function;
 - ii. Use of the traffic display range selection depending on the air traffic environment and its use to reduce the display range to increase display resolution when an advisory is issued;
 - iii. Recommended use of the 'Above/Below' mode selector during climbs and descents;
 - iv. If available, the proper selection of the display of absolute or relative altitude and the associated limitations.
- b. Enable the pilot to correctly interpret the information displayed by ACAS:
 - i. Other and proximate traffic;
 - ii. Non-altitude reporting traffic;
 - iii. No bearing TAs and RAs;
 - iv. Off-scale TAs and RAs;
 - v. RAs - information displayed on the traffic display and the meaning of the red and green areas on the RA display;
 - vi. Knowledge of when the green areas will and will not be displayed;
 - vii. An understanding of the RA display limitations, ie. if a vertical speed tape is used and the range of the tape is less than 2500 ft per minute, how an increase rate RA will be displayed;
 - viii. How a 'Track Up' display will require the pilot to make a mental adjustment for drift when assessing relative bearing of a potential threat.
- c. Ensure that the pilot has an understanding of the use of TA-only mode including:
 - i. A knowledge of the operator's guidance for the use of TA-only mode;
 - ii. The reason for using this mode and situations in which its use may be desirable;
 - iii. That TA aural annunciations are inhibited below 500 ft AGL.
- d. Ensure that pilots know the combined crew actions when responding to TAs and RAs including:
 - i. Crew duties when a TA is issued;
 - ii. Crew duties and call-outs when responding to an RA with a clear definition of who will fly the aircraft during a response to an RA;
 - iii. When in receipt of simultaneous and conflicting instructions to manoeuvre from ATC and an RA, the RA is followed and ATC are notified using the standard phraseology;
 - iv. Communications with ATC during an RA;
 - v. Conditions under which an RA will not be followed and who will make that decision.
- e. Ensure that pilots are aware of the requirements for reporting an RA to ATC and other authorities.

3 Manoeuvre Training

3.1 The training of pilots to correctly respond to ACAS displayed information is best conducted in a full flight simulator equipped with ACAS. The simulator should have controls and displays that are similar in appearance and operation to those in the aircraft.

3.2 If the operator does not have access to an ACAS-equipped simulator, the initial training should be conducted by means of interactive CBT. The ACAS display and controls should be similar to those on the aircraft the pilot will fly. The interactive CBT display should display scenarios in real time. The pilot must be able to identify when the correct response has been made and what response should have been made following an incorrect response.

3.3 The manoeuvre training should cover a broad variety of scenarios so that the crews can experience the full capability of the ACAS equipment. This training should also include demonstrations of the consequences of slow or late response, and manoeuvring in opposition to the direction of the displayed RA.

a. TA response:

- i. The division of duties between the pilot flying and the pilot monitoring. The pilot flying should continue to fly the aircraft and be prepared to respond to any RA that might follow;
- ii. The proper interpretation of the displayed information - bearing, range, data tag and trend arrow;
- iii. Commence a visual search for the traffic causing the TA;
- iv. Not to manoeuvre based solely on the ACAS displayed information due to azimuth resolution limitations;
- v. When visual acquisition is attained, the right of way rules should be used to maintain or attain safe separation;
- vi. To ensure that no unnecessary manoeuvres are initiated and that the limitations of making manoeuvres based solely on visual acquisition are understood.

b. RA response:

- i. The division of duties between the pilot flying and the pilot monitoring;
- ii. The proper interpretation of the displayed information;
- iii. For an RA response requiring a change in vertical speed, it is initiated in the correct direction within five seconds of the RA being displayed;
- iv. For increase rate, reversal, weakening and strengthening RAs the vertical speed modification or reversal manoeuvre is initiated within two and a half seconds of the RA being displayed;
- v. The recognition of altitude crossing encounters and the proper response to these RAs;
- vi. For RAs that do not require a change in vertical speed, the vertical speed needle or pitch angle remains outside the red area of the RA display;
- vii. For maintain rate RAs, the vertical speed is not reduced. Pilots should recognise that a maintain rate RA may result in crossing through the intruder's altitude;
- viii. If a justified decision is made not to follow an RA, the resulting vertical rate is not in a direction opposite to the sense of the displayed RA;
- ix. The deviation from the current clearance is minimised by levelling the aircraft when the RA weakens or when 'Clear of Conflict' is annunciated and a prompt return to the current clearance is executed;
- x. When possible an ATC clearance is complied with while responding to an RA. For example, if the aircraft can level at the assigned altitude while responding to a reduce climb or reduce descent RA, it should be done;
- xi. A knowledge of the ACAS multi-aircraft logic and that ACAS can optimise separation from two aircraft by climbing or descending towards one of them;
- xii. A prompt response is made when a climb RA is issued at the aircraft's maximum altitude, even if the rate of climb demanded cannot be achieved.

4 Initial Training

4.1 The pilot's understanding and competence in the operation of ACAS should be checked in a full flight simulator equipped with an ACAS display and controls that are similar to those in the aircraft the pilot will fly. The simulator should be able to generate a range of scenarios that include:

- Initial RAs requiring a change in vertical speed;
- Initial RAs that do not require a change in vertical speed;
- Maintain rate RAs;
- Altitude crossing RAs;
- Increase rate RAs;
- RA reversals;
- Weakening RAs issued while the aircraft is at the maximum altitude;
- Multi-aircraft RA encounters.

4.2 If an operator does not have access to an ACAS-equipped full flight simulator then the pilot's understanding and competence in the operation of ACAS should be checked using interactive CBT with an ACAS display and controls similar in appearance and operation to those in the aircraft the pilot will fly. The CBT should include all types of RAs in paragraph 4.1 above.

5 Recurrent Training

5.1 ACAS recurrent training ensures that pilots maintain the appropriate knowledge and skills in the operation of ACAS. The recurrent training should be integrated into and/or conducted in conjunction with other established recurrent training programmes.

5.2 The recurrent training should include significant issues and operational concerns that have been identified by the operator.

5.3 Recurrent training should include both academic and simulator manoeuvre training and address any significant issues identified by line operations, equipment or procedural changes or operations in airspace where high numbers of TAs and RAs have been reported.

5.4 ACAS monitoring programmes periodically publish findings from the analyses of ACAS events. The results of these analyses typically discuss technical and operational issues and are therefore a good source of information that should be included in the planning of the recurrent training.

5.5 Where recurrent training is conducted in a simulator, pilots should fly all the RA scenarios listed in paragraph 4.1 above over a four-year period.

5.6 Where recurrent training is conducted using CBT, pilots should fly all the RA scenarios listed in paragraph 4.1 above over a two-year period.

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